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The "Royal Charter" Storm of 1859

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Abstract

On 25 and 26 October 1859, the British Isles were hit by a severe storm, named after the ship "Royal Charter" that sank nearby Anglesey, England. At that time Robert FitzRoy, a former officer of the Royal Navy, recorded the course of events and produced hand-drawn weather maps. Today the Twentieth Century Reanalysis (20CR) version 2c provides new insight into the incident. 20CRv2c is used in this study to analyse the development and evolution of the storm. Further, the reanalysis is assessed in a comparison with historical documents. During the analysed period (24-27 October 1859), the 20CRv2c ensemble mean describes a trough with an embedded low-pressure system centred over the British Isles with a cyclonic circulation at the surface. However, the associated winds underestimate the values reported in the historical sources. The jet stream at higher levels is not co-located but south of the storm. A deeper look into individual members of 20CRv2c shows a large variability among them with a different position, timing and intensity of the low-pressure system. Although some members do produce a strong storm, the ensemble does not cover the observed strength and timing of the storm.

1. Introduction

The "Royal Charter" storm on 25-26 October 1859 is regarded as one of the strongest storms affecting the Irish Sea during the 19th century. The storm was named after the ship "Royal Charter" (Fig. 1), which was caught by the storm on its way from Australia to the United Kingdom. Approximately five hundred passengers and a huge amount of precious gold bullions were on board of the ship. After a brief stop in Queenstown, in the south of Ireland,

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the “Royal Charter” took off on 25 October 1859 to its final destination Liverpool (Booth, 1970).

During the night the winds intensified and the ship anchored off the north coast of Anglesey to wait for the storm to die down. Nevertheless, in the morning of 26 October 1859 the ship was smashed to pieces when the strong winds pushed it onto the cliffs of Moelfre, a village on Anglesey's north-eastern coast. Around 450 persons on the Royal Charter died, the total loss of lives of the storm was around 800.

The “Royal Charter” storm had lasting effects on meteorology in Britain and around the world (for the following see Booth, 1970; Burroughs, 1993; Lamb and Frydendahl, 1991; Anderson, 2005; Moore, 2015). Already in the 1854, the Meteorological Department (which later became the Met Office), led by Admiral Robert FitzRoy, had planned a storm warning system. The “Royal Charter” tragedy shocked Britain so deeply that preventing similar future catastrophies became an important issue. After this event, the warning system was approved and put into service in 1860. Initially, thirteen observing stations at telegraph stations transmitted daily observations to the headquarters in London (a similar system was built in the Netherlands). Warnings were telegraphed back to the stations, where visual signs were raised to warn the ships. The system caused tremendous public debate, though it was arguably effective in warning ships in British coastal waters (Moore, 2015). Then, in August 1861, the first meteorological forecast was printed in a newspaper. The fact that a government agency issued an (unauthorized) forecast led to an even more heated and lasting debate, perhaps contributing to the tragic suicide of FitzRoy in 1865.

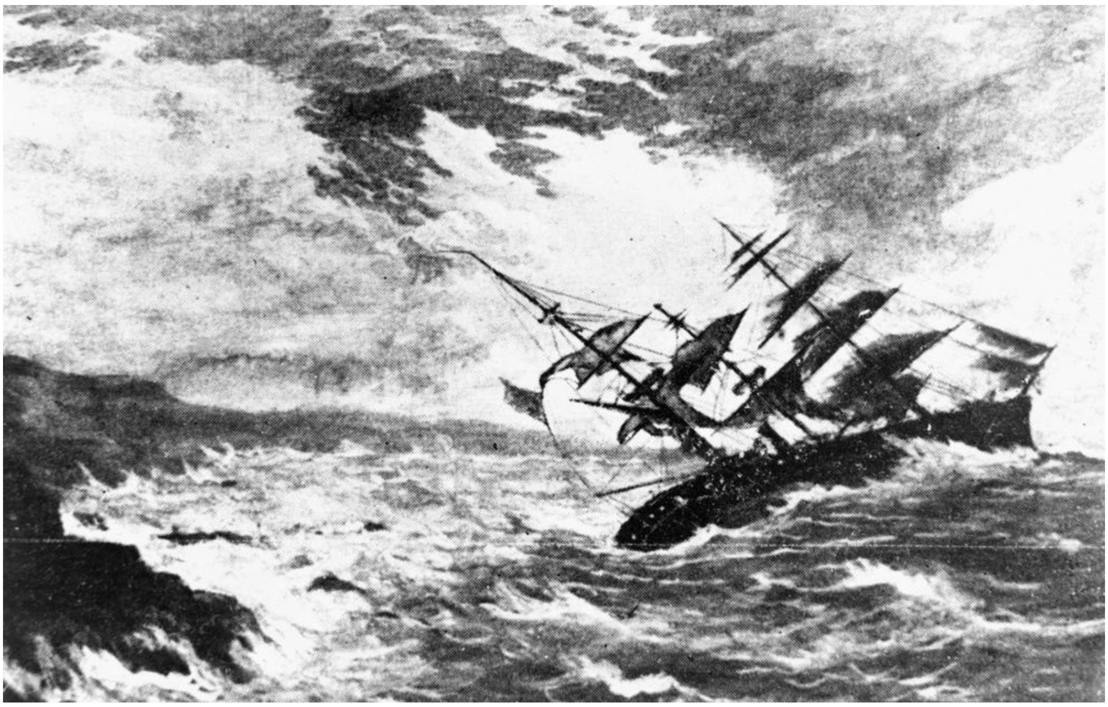

Figure 1: Undated painting of the Royal Charter by an unknown artist. Image credit: State Library of Queensland.

Detailed weather maps and a description of the “Royal Charter” storm were produced by FitzRoy (1860; cited in Lamb and Frydendahl, 1991). In the following, these historical sources are compared to the fields of the 20CRv2c dataset. This study aims at answering two research questions: Is the “Royal Charter” storm system reproduced in 20CRv2c? Is the “Royal Charter” storm in the reanalysis qualitatively comparable to FitzRoy’s weather interpretations and weather maps? Two further storms over Western Europe are studied in the papers of Meyer et al. (2017) and Ernst at al. (2017) in this volume.

The paper is organised as follows. Section 2 describes the reanalysis data and the methods used to compare the historical data with the reanalysis data. The results are illustrated in Section 3 and discussed in Section 4. Finally, the conclusions are drawn in Section 5.

2. Data and Methods

All reanalysis data used in this study originate from the Twentieth Century Reanalysis, version 2c (20CRv2c; Compo et al., 2011). The reanalysis is based on the assimilation of surface observations of synoptic pressure from the International Surface Pressure Databank (Cram et al., 2015) into a model that uses monthly sea-surface temperature and sea ice distribution (Giese et al., 2016; Hirahara et al., 2014; see Brönnimann, 2017 for details on all data sets used in this book) as boundary condition. By means of an Ensemble Kalman Filter data assimilation, the most likely state of the global atmosphere is estimated. 20CRv2c reaches as far back as 1851, with a six-hourly temporal resolution. Note, however, that the data coverage is poor in the beginning of the data set. For the case of the “Royal Charter” storm, Figure 2 shows the observations assimilated into 20CRv2c for the analysis at 12 UTC, 25 October 1859. Only two stations were within 1000 km distance of Anglesey.

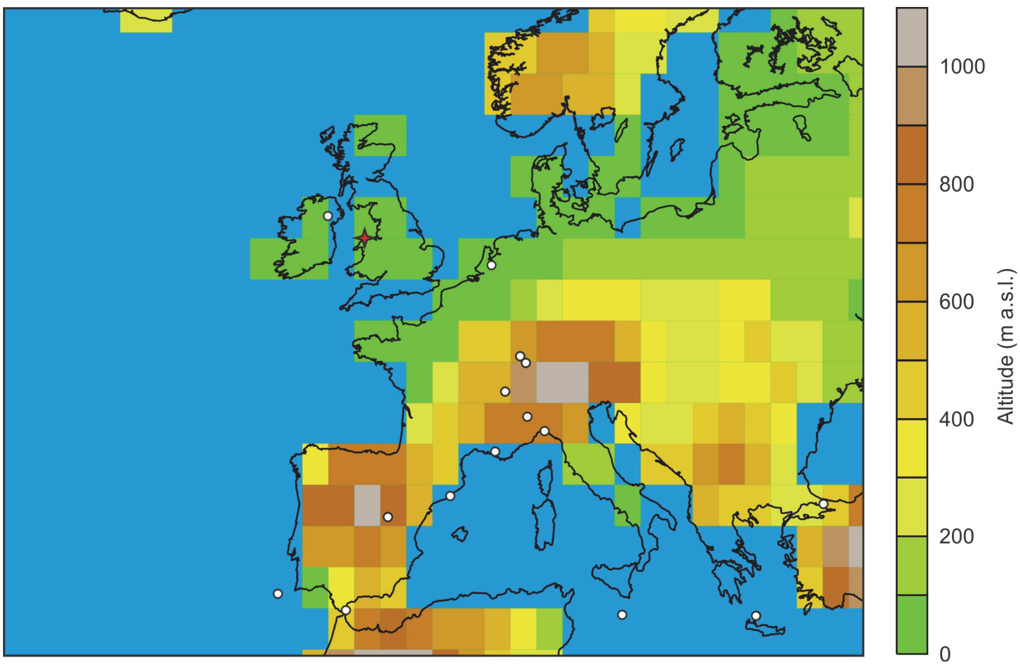

Figure 2. Topography of the 20CRv2c dataset. White dots show all observations assimilated into 20CRv2c from 06 to 12 UTC on 25 October 1859. The location of Anglesey is marked with a red star.

20CRv2c is an ensemble product with 56 individual members, which provides some information on uncertainty (see Brönnimann, 2017). In this paper we use first the ensemble mean and then analyse individual members.

To analyse the "Royal Charter" storm, we analyse data from 24-27 October 1859 within a spatial domain reaching from 30° W to 32° E and 34° N to 64° N. The variables investigated are the geopotential height (GPH) at 500 hPa, pressure reduced to mean sea level (SLP), wind at 850 hPa and wind at 250 hPa.

The reanalysis is compared with historical weather charts based on FitzRoy. One of FitzRoy's charts is reproduced in Figure 3. However, Lamb and Frydendahl (1991) point out that FitzRoy's maps are difficult to interpret and that only temperature measurements provide reliable information. We therefore use the weather charts drawn by Lamb and Frydendahl (1991), but which are based on FitzRoy's charts.

In the following, FitzRoy's view of the "Royal Charter" storm is first established in the frame of a literature review, mainly based on Lamb and Frydendahl (1991). Second, the historical information is compared to selected variables from the reanalysis. In the comparison the ensemble mean as well as individual ensemble members are considered.

Figure 3. One of the original charts produced by FitzRoy to demonstrate his understanding of the "Royal Charter" storm. Wind strength is shown by the length of the line, red and blue lines represent pressure and temperature and weather conditions such as cloud and rain are shown by the markings in the small boxes (Information provided by the National Meteorological Library and Archive – Met Office, UK).

3. Results

In the following three sections the results from the literature (Sect. 3.1) and from the 20CRv2c reanalysis (Sect. 3.2, 3.3) are illustrated.

3.1. FitzRoy's weather interpretations and historical maps

From the information in Lamb and Frydendahl (1991), the track of the cyclone can be reconstructed (Fig. 4). The storm depression, first noticed in the Bay of Biscay near Cape Finisterre on 24 and 25 October 1859, reached the British Isles on 25 October 1859. On the next day, the cyclone made its way from Cornwall to Yorkshire coast near Flamborough Head. From there it moved along the coast of Scotland until it reached the North Sea between Shetland Isles and Norway on 27 October 1859 (Lamb and Frydendahl, 1991).

Portugal, Spain, France and the south of the British Isles experienced strong SE or SW winds on 25 October 1859. In the course of the day and on 26 October 1859 a sharp shift from southerly to northerly winds took place over England, Wales and Scotland. The strongest winds occurred in the Irish Sea on 25 and 26 October 1859, in the shape of a narrow stream from N or NNE. According to FitzRoy the wind gusts reached a speed of 26-44 m s^{-1} (52-87 knots). However, when the cyclone crossed England an area of 15-25 km width in its centre remained calm (Lamb and Frydendahl, 1991).

Based on FitzRoy's weather maps, Lamb and Frydendahl (1991) propose two weather maps showing the wind pattern and pressure fields in the morning of 25 and 26 October 1859 (Fig. 5). The winds responsible for the sinking of the "Royal Charter" are associated with a slow moving cold front. The area affected by strong winds did not exceed a scale of 300-500 km. Gale winds arose on an even smaller scale. Thus, the storm had a rather small spatial extension. The storm developed near the trough axis, therefore Lamb and Frydendahl (1991) did not expect a jet stream along the storm's track.

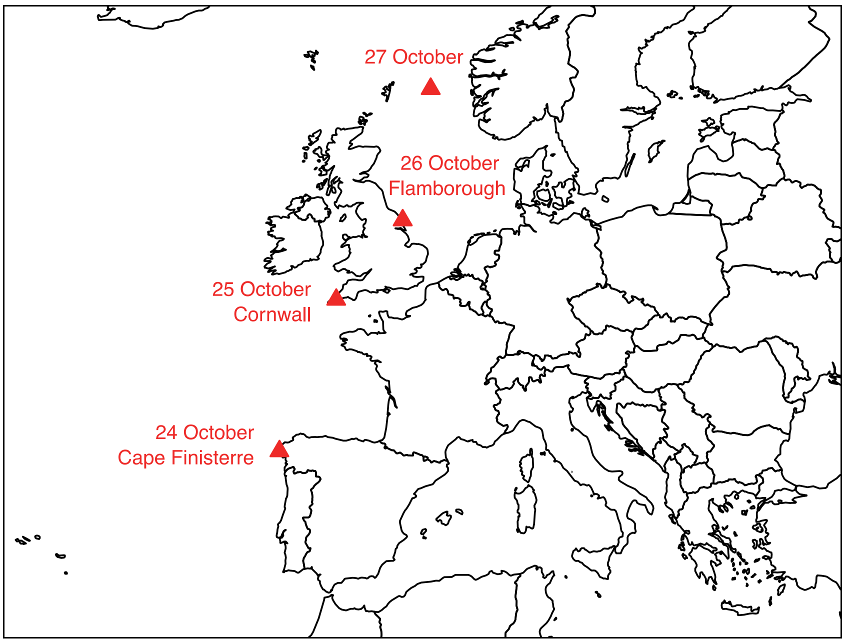

Figure 4: Track of the "Royal Charter" storm according to the description in Lamb and Frydendahl (1991).

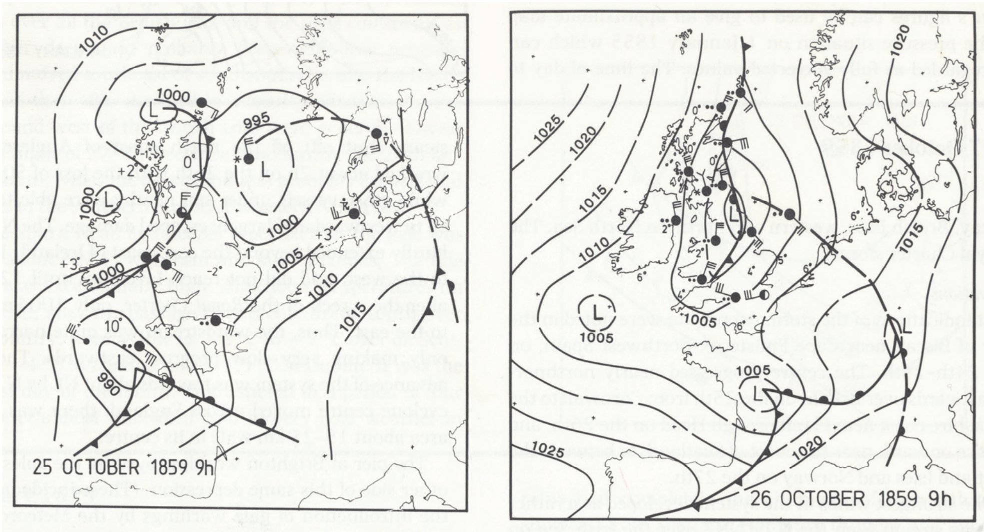

Figure 5: Weather map of 25 October 1859 at 09:00 a.m. (left) and 26 October 1859 at 09:00 a.m. (right) reconstructed by Lamb and Frydendahl (1991) based on FitzRoy's hand-drawn weather maps.

In the following we describe the weather maps reconstructed by Lamb and Frydendahl (1991) based on FitzRoy's maps. On 25 October 1859 four low-pressure systems surrounded the British Isles. The most pronounced system, with a minimum pressure of 990 hPa and an evolved front, was located over the Bay of Biscay. Two low-pressure systems, with a minimum pressure of 1000 hPa, were located north and north-west of the British Isles. The former had a cold front, elongated to the Anglesey coast, with strong winds of 12-16 m s^{-1} (23-32 knots) and overcast clouds. A fourth low-pressure system, with a minimum pressure of 995 hPa and a cold front, was located between Shetland Isles and Norway.

The next day, again four low-pressure systems are seen on the map, two north of the British Isles, one east of the British Isles and one over the east coast of the British Isles near Flamborough. The latter system, with a minimum pressure of 990 hPa, was the strongest of the four. It was accompanied by strong winds of 16 m s^{-1} (32 knots) and overcast sky. The central pressures of the remaining three cyclones were about 1005 hPa.

3.2. The "Royal Charter" storm in the 20CRv2c ensemble mean

The 20CRv2c ensemble mean 500 hPa GPH shows a trough centred over the British Isles during the whole period (Fig. 6). The trough was most pronounced on 24 and 26 October 1859 with values around 520 geopotential decametres (gdm) and weakened on 27 October 1859. The SLP field displays a strong low-pressure system during the first two days centred over northern England and during the last two days centred over central England.

According to the 20CRv2c ensemble mean of the 850 hPa wind field (Fig. 7, calculated from the ensemble mean *u* and *v*), the British Isles were more or less located in the centre of the cyclonic rotation. Therefore, the winds near Anglesey were calm with 4-6 m s^{-1} during the analysed period. The north-western coast of the British Isles were in a north-easterly wind field. In this region, the wind speeds were highest on 24 October 1859 when values of 12-16 m s^{-1} are found in 20CRv2c. The south-westerlies of the cyclone, passing by the southern-east coasts of the British Isles, were strongest on 26 October 1859 when a maximum of 22 m s^{-1} was reached. On 27 October 1859 the cyclonic circulation disappeared.

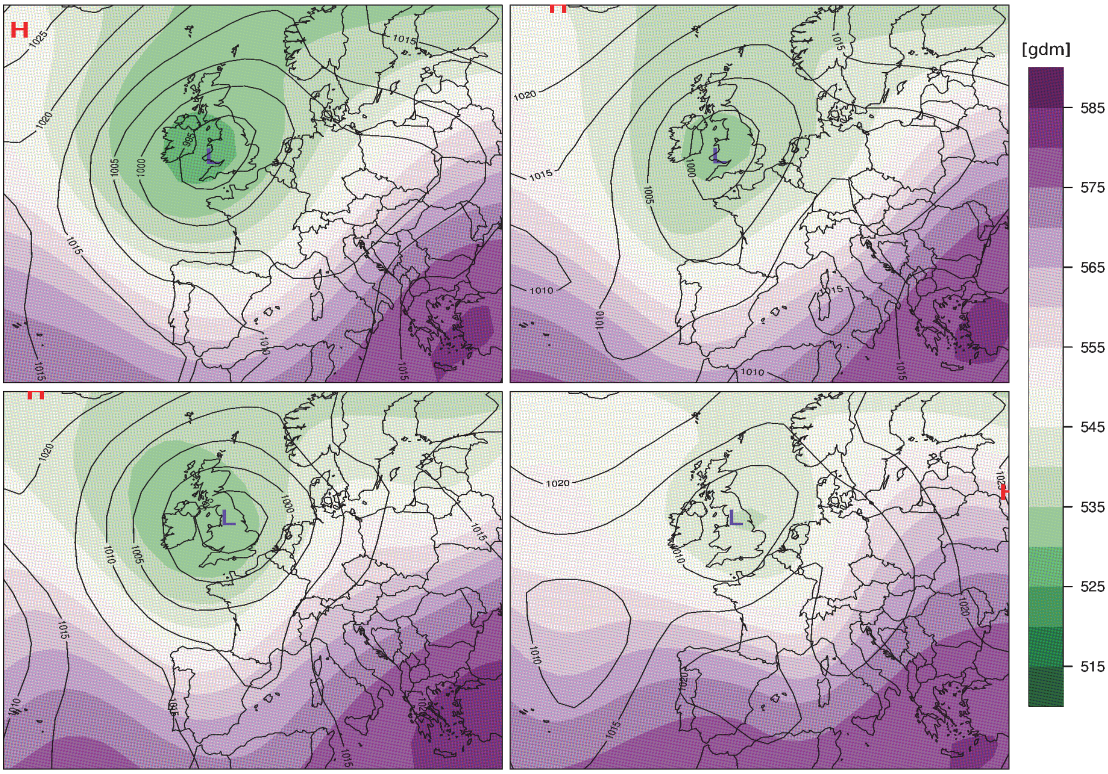

Figure 6. 20CRv2c ensemble mean of 500 hPa GPH (colours) in gdm and SLP (contours) in hPa for 24 October (upper left), 25 October (upper right), 26 October (lower left), and 27 October 1859 (lower right) at 12 UTC. The lowest and highest values of the SLP field are marked with an L and an H, respectively.

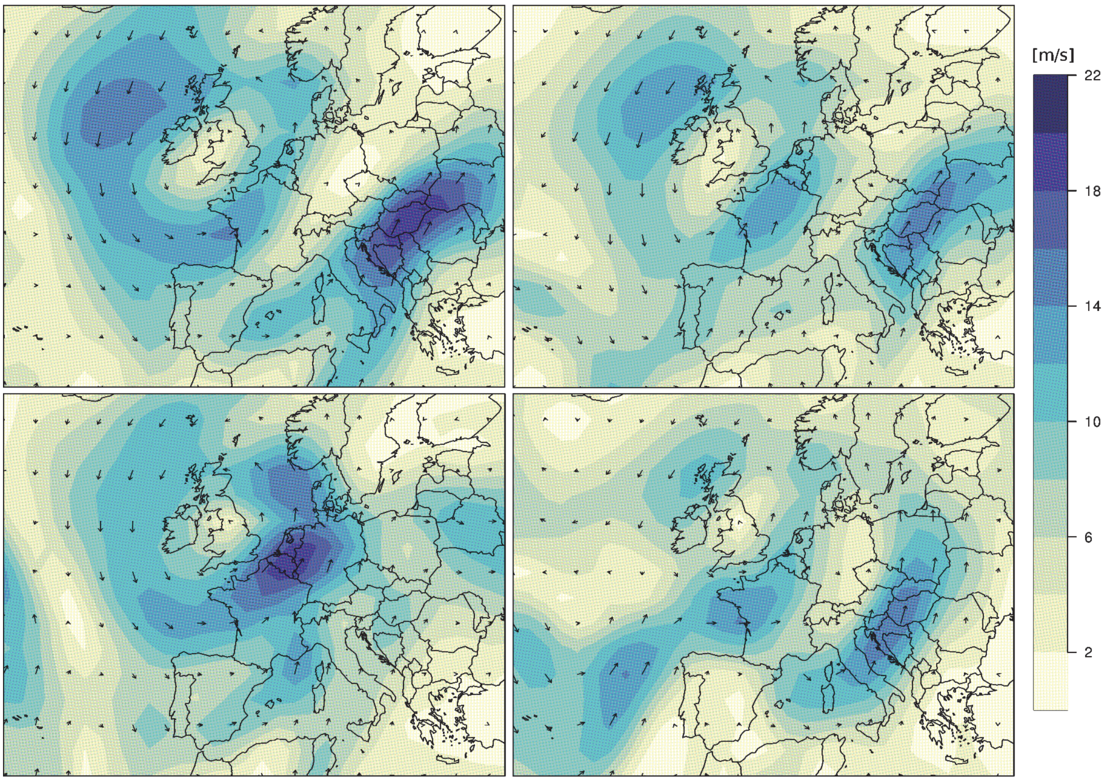

Figure 7. 20CRv2c ensemble mean of 850 hPa wind (vectors) in m s^{-1} for 24 October (upper left), 25 October (upper right), 26 October (lower left), and 27 October 1859 (lower right) at 12 UTC. The colour indicates wind speed as calculated from the ensemble mean *u* and *v*.

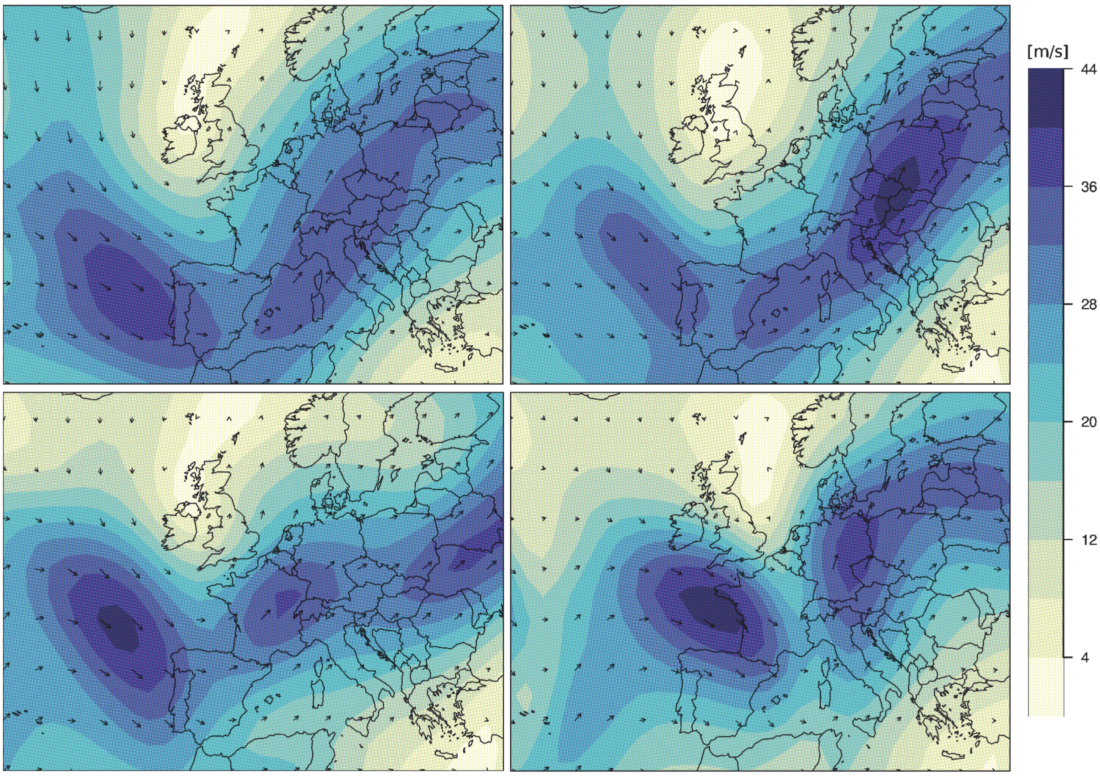

Figure 8. 20CRv2c ensemble mean of the wind speed (shaded colors) at 250 hPa in m s^{-1} and the wind direction represented as arrows for 24 (upper left), 25 (upper right), 26 (lower left) and 27 October 1859 (lower right) at 12 UTC. The wind arrows are scaled according to the wind speed.

Finally, the 20CRv2c ensemble mean of the wind at 250 hPa (Fig. 8) shows the jet stream passing south of the British Isles. Strong north-westerlies were present west of the British Isles and strong south-westerlies east of the British Isles. On all four days wind speeds of 40-44 m s^{-1} (calculated from ensemble mean *u* and *v*) were reached. In accordance with the location near the trough axis, the wind conditions aloft the British Isles were calm.

3.3. The "Royal Charter" storm in the 20CRv2c ensemble members

Time series of SLP and wind at 850 hPa taken at the location of Anglesey (4°19 W, 53°16 N, Fig. 8) show a large variability among the 56 ensemble members. We selected three members, which exhibit maximum wind speed values between 18 and 23 m s^{-1}, but with a different time evolution. In the first member (#39, Fig. 9, red line) the maximum wind speed was reached on 25 October 1859, 18 UTC, followed by a rapid weakening. In the second selected member (#51, Fig. 8, green line), the maximum was reached on 26 October 1859 at 18 UTC, extending until the next day. In the third member shown (#5, Fig. 9, blue line) the maximum is found on 27 October 1859 at 12 UTC, again followed by a rapid decrease of the wind speed. The development of the SLP is very similar for all three members with minima of 990 hPa (Fig. 9, red and blue lines) or 995 hPa (Fig. 9, green line) during 26 October 1859.

All three selected ensemble members show a trough centred above the British Isles with a low-pressure system near the trough axis (Fig. 10). However, the position of the low-pressure system differs. In member #5 (Fig. 10, left) it is located over the North Sea, in member #39 (Fig. 10, middle) off the south-western coast of England and in member #56

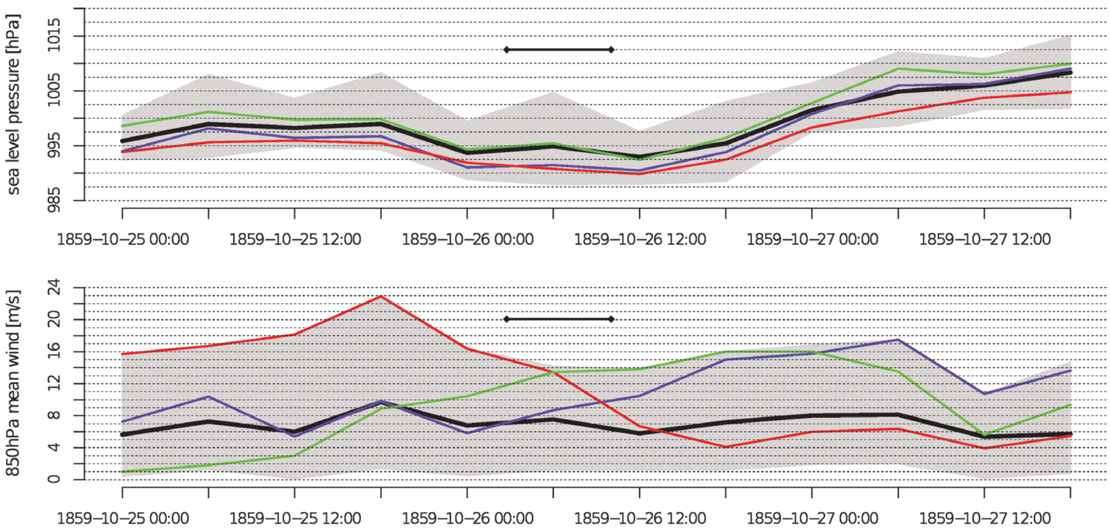

Figure 9. Temporal evolution of (top) sea-level pressure in hPa and (bottom) wind at 850 hPa in m s^{-1} in Anglesey from 25 to 27 October 1859. The ensemble mean is shown in a thick black line, the ensemble spread in grey and the members are coloured individually: member #5 (blue), #39 (red) and #51 (green). The time window in which the "Royal Charter" sank is marked with a black line that ends in a dot on both sides.

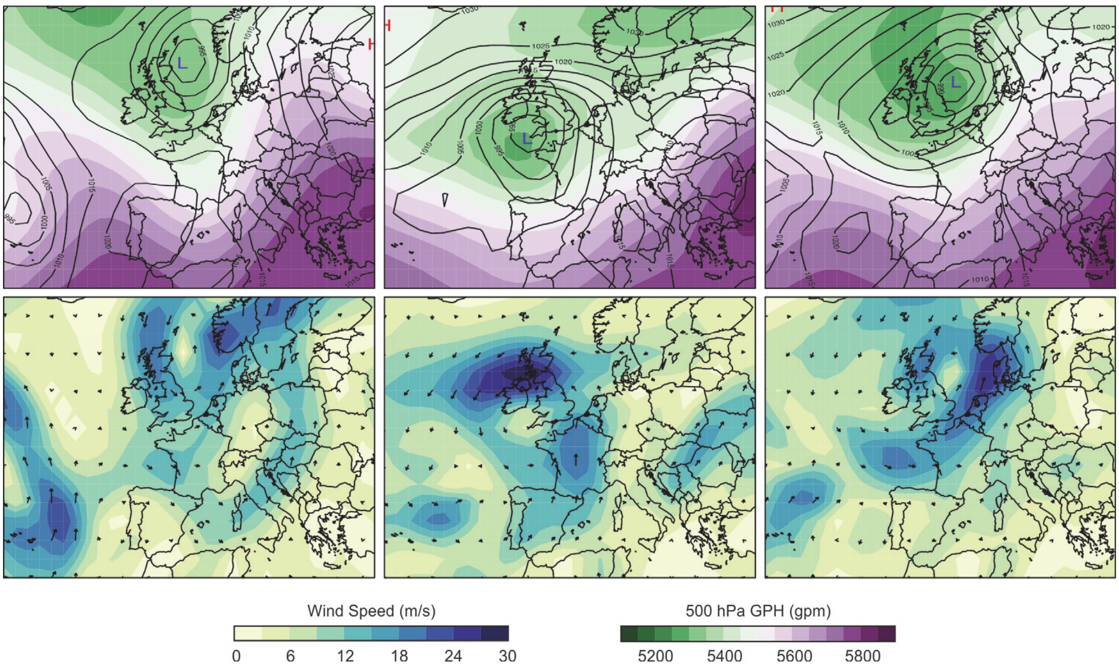

Figure 10. (top) GPH at 500 hPa in gdm (shaded colors) and SLP in hPa (contours) and (bottom) wind speed at 850 hPa in m s^{-1} (shaded colors) and wind direction indicated as arrows for the 20CRv2c ensemble member #5 on 27 October 1859 at 06:00 UTC (left), member #39 on 25 October 1859 at 18:00 UTC (middle), and member #51 on 25 October 1859 at 18:00 UTC (right).

(Fig. 10, right) again over the North Sea. In members #39 and #51, the central pressure of the cyclone amounts to 990 hPa, in member #5 the central pressure is 995 hPa.

All three members show a cyclonic wind field. In members #5 and #51 the cyclone is located such that northerlies and north-easterlies arise over the Irish Sea. In member #39, the north of the British Isles is affected by westerlies, while the south lies in the relatively calm storm centre. Wind speed maxima of 21-30 m s^{-1} are found in the members.

4. Discussion

According to Lamb and Frydendahl’s (1991) interpretation based on FitzRoy’s notes, a low-pressure system centred near the east coast of England in the morning of 26 October 1859 was responsible for the N or NE winds shipwrecking the “Royal Charter”. This low-pressure system moved from the Bay of Biscay across England to the North Sea. On the weather map describing the situation in the morning of 26 October 1859 (Figs. 3, 5), the low-pressure system is displayed with a minimum pressure of 995 hPa and is associated with wind speeds of 16 m s^{-1}. However, FitzRoy estimated the highest gusts of wind to 26-44 m s^{-1}. Other characteristics of the storm are its position close to the trough's centre, a calm centre and an overall small spatial extension (Lamb and Frydendahl, 1991).

The 20CRv2c ensemble mean meets Lamb and Frydendahl’s (1991) interpretation in several aspects. A trough centred above the British Isles with a low-pressure system close to the trough's axis is reconstructed by the reanalysis. The low-pressure system - similar to Lamb and Frydendahl’s respectively FitzRoy’s weather map (Figs. 3, 5) - has a minimum pressure of 995 hPa on 26 October 1859. The wind field at 850 hPa represents the calm storm centre above England. The jet stream aloft – as expected with the storm’s position close to the trough axis - is not co-located with the storm. However, the storm’s propagation from the Bay of Biscay to the North Sea is not observable in the reanalysis mean. Furthermore, the wind speeds at 850 hPa are lower than proposed by Lamb and Frydendahl (1991) or FitzRoy (1860; cited in Lamb and Frydendahl, 1991) and the maximum wind speeds are over Ireland rather than near Anglesey. There is no N or NNE flow evident above the Irish Sea.

The 20CRv2c ensemble mean is however not enough to perform a complete analysis of the event. A closer look at the ensemble spread and three individual members reveals a large variability in the reanalysis. It shows the importance of having a large panel of members, especially for early events like the “Royal Charter” storm. The ensemble mean does not capture the details of the event and there is a large spread among the ensemble members. The ensemble mean underestimates extremes (see Brönnimann, 2017), particularly as tracking the strongest observed storms carries a selection bias. It is therefore more relevant to know whether the ensemble as a whole contains the observed event.

The analysis of the ensemble members reveals that the low-pressure system and the strong winds associated are not well captured by member #39. Members #5 and #51 give a more realistic situation with northerly wind components near Anglesey. The wind speeds proposed by the individual members are higher than the ones of the ensemble mean. However, none of the members reports wind speeds as high as described by the historical sources.

5. Conclusions

In a first step, we established FitzRoy’s view on the “Royal Charter” storm. Next, we compared the historical information to selected mean variables from the reanalysis. Finally, we looked at the ensemble spread and three specific members.

From the comparison we conclude that the storm is reproduced in the reanalysis, *i.e.,* we could find a cyclone over the British Isles during the period proposed by the historical source. However, the exact location of the cyclone – in the ensemble mean, but also in one of the investigated members – does not meet the situation described by FitzRoy. We could find northerly winds at Anglesey in two of the members. Nevertheless, here the timing of the wind maxima does not coincide with the destruction of the "Royal Charter". Furthermore, both the mean and the members report wind speed maxima below the speed proposed by FitzRoy. On that scale, the "Royal Charter" storm in the reanalysis is not comparable to FitzRoy's weather interpretations and weather maps, although 20CRv2c reproduces the synoptic scale situation relatively well.

Acknowledgements

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